OLIVE-SIDED FLYCATCHER NESTING SUCCESS IN WESTERN MONTANA

2001 PILOT STUDY

FINAL REPORT

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INTRODUCTION

The olive-sided flycatcher (*Contopus cooperi*) is a neotropical migrant songbird that breeds in mid to high elevation semi-open forest and along forest edges and openings, such as burns, meadows, and harvest units (Altman & Sallabanks 2000). This flycatcher is currently listed as a Sensitive Species by the U.S. Forest Service (USFS) in the Rocky Mountain Region (Finch 1992), as a Species of Concern by the Montana Natural Heritage Program and Montana Fish, Wildlife, and Parks (Carlson 2001), and as a Species of Management Concern by the Office of Migratory Bird Management in six of seven U.S. Fish and Wildlife Service (USFWS) regions (1995). In addition, the Montana Bird Conservation Plan lists the olive-sided flycatcher as one of fourteen high priority (level 1) species in need of immediate conservation action (Montana Partners in Flight 2000).

Data collected by the Breeding Bird Survey (BBS) from 1966-1996 indicate a 3.9% annual decline in olive-sided flycatcher populations throughout its breeding range (Sauer et al. 1997). Idaho and Montana have experienced the greatest negative trends for olive-sided flycatchers of any western states, with populations in Montana declining 4.2% annually from 1966-1979 and 6.2% from 1980-1996 (Sauer et al. 1997).

Despite overall declines in olive-sided flycatcher abundance, many studies report increased detections following selective harvest with at least 30% green tree retention (Medin & Booth 1989; Franzreb & Ohmart 1978). In western Montana and Idaho, these flycatchers are most abundant in three harvest types: seed tree cuts, old clearcuts and young clearcuts (Hutto & Young 1999). Historically, these birds were likely restricted to early post-fire habitat (Hutto 1995). The paradox of declining populations despite increasing open and semi-open habitat created by harvest may represent an "ecological trap" (Hutto & Young 1999), in which structural features in harvest units resemble natural forest edges and openings, but do not in fact offer high quality breeding habitat. While few studies have focused on olive-sided flycatchers, Altman (2000) found greater nest success in post-fire habitat than in harvest units in the Cascade Mountains of northwest Oregon.

Many factors may be responsible for declining olive-sided flycatcher populations, among them destruction and fragmentation of habitat on the breeding and non-breeding grounds (Altman & Sallabanks 2000). A number of studies suggest breeding success may be the most important factor underlying long term declines in songbird populations (Martin 1992, Sherry 1984). Potential factors limiting success on the breeding grounds include reduced prey availability, nest predation, loss of tall snags and trees, and habitat loss and alteration due to timber harvest and fire suppression (Altman 1998, Altman & Sallabanks 2000, Finch 1992).

In a review of twenty-six studies, Martin (1992) concluded that predation is the primary cause of nest failure for open-cup nesting songbirds and that nest concealment is correlated with success in many species. However, nest concealment does not appear to correlate with success for this species since adult olive-sided flycatchers are known to defend their nests vigorously (Altman 2000). Thus, causes of increased susceptibility to nest predation may be complex. For example, both an open forest structure and availability of perch sites near the nest may facilitate early detection of potential nest predators and their deterrence by olive-sided flycatchers.

To address concerns over declining olive-sided flycatcher populations, we initiated a pilot study to investigate factors affecting nesting success in forested landscapes in western Montana.

OBJECTIVES

The primary objective of the 2001 field season was to assess the logistics, amount of effort, cost, and overall feasibility of locating sufficient numbers of nests to examine factors affecting olive-sided flycatcher nesting success. Our research efforts focused on addressing the following questions:

1. Can habitat used by olive-sided flycatchers be classified into distinct forest types; particularly, can managed forest be classified into distinct stand types?
2. Does olive-sided flycatcher nesting success vary among forest and harvest types?
3. Are habitat or vegetation characteristics correlated with nest success, e.g. canopy cover, shrub density, tree species and size class, and stand type?
4. Are basic life-history traits for olive-sided flycatchers in Montana comparable to those reported in studies conducted elsewhere?

STUDY AREA

The study area is in the Seeley Lake district of the Lolo National Forest, and is delineated by Clearwater and Uhler Creeks to the north, the Swan Range to the east, Placid Creek to the south, and the Mission Mountains Wilderness to the west; roughly within T17N R15, T17N R16, T18N R16W, and T18N R15W (Figure 1).

The study area includes federal, state, and private lands in a mosaic of managed forests where timber harvest is the predominant land management activity affecting olive-sided flycatcher habitat. Mixed forest including Douglas-fir (*Pseudotsuga menziesii*), western larch (*Larix occidentalis*), lodgepole pine (*Pinus contorta*), and ponderosa pine (*Pinus ponderosa*) dominate south and west aspects at lower elevations in the study area, with some pure stands of Douglas-fir (U.S. Forest Service 1997). Mid-elevation forests in the study area are dominated by mixed to single-species stands of seral Douglas-fir, western larch, and lodgepole pine. Subalpine fir (*Abies lasiocarpa*), whitebark pine (*Pinus albicaulis*), and Engelmann spruce (*Picea engelmannii*) are most abundant at high elevations.

Forests within the study area historically experienced low frequency, stand-replacing fires that created even aged stands in a mosaic of early seral to old-growth forest stands across the landscape (Fischer and Bradley 1987). However, dense stands are now common in the study area due to timber harvest and fire suppression over the past century.

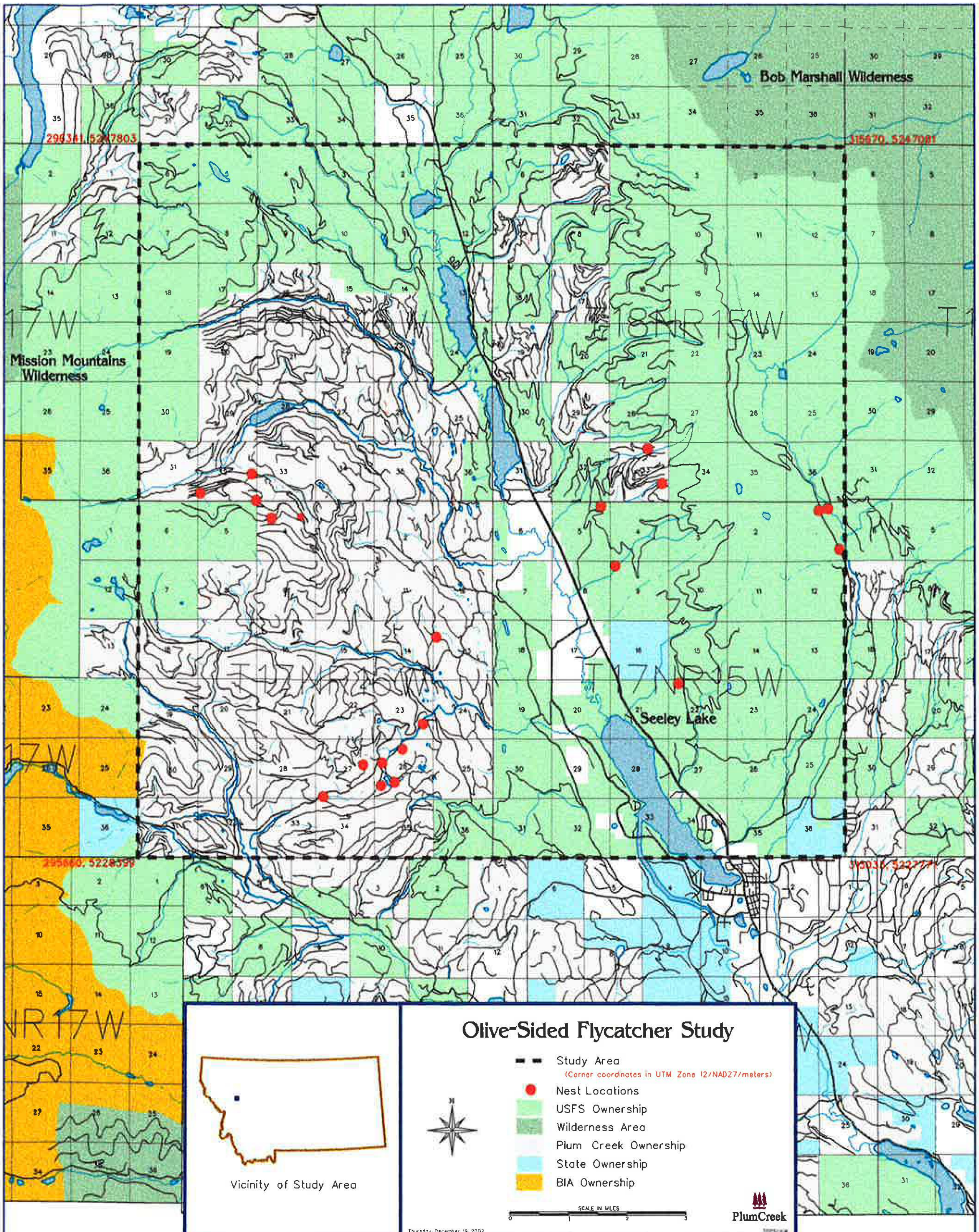
Bob Marshall Wilderness
Mission Mountains Wilderness
Seeley Lake
T18NR15W
T17NR16W
T17NR15W
296341, 5247803
315670, 5247081
295860, 5228399
315036, 5227771
Olive-Sided Flycatcher Study
Study Area
(Corner coordinates in UTM Zone 12/NAD27/meters)
Nest Locations
USFS Ownership
Wilderness Area
Plum Creek Ownership
State Ownership
BIA Ownership
Vicinity of Study Area
SCALE IN MILES
0
1
2
3
PlumCreek
Thursday, December 19, 2002

Figure 1.

METHODS

The Seeley study area was chosen based on prior knowledge of abundance of olive-sided flycatchers in the area (Hutto and Young 1999, T. Smucker, personal observations), property ownership and accessibility, and anticipated feasibility of adequately surveying the area. Surveys started by following forest roads to the east and west of state highway 83, alternating east and west by day, and following all forest roads and spurs encountered.

The study was conducted in two phases. Between mid-May and mid-June we conducted surveys for singing males along secondary and tertiary forest roads in the study area. Using vehicles or mountain bikes we made stops at 400 meter intervals to listen for five minutes, or until an olive-sided flycatcher was detected. Additional surveys were conducted on foot along trails and tops of ridges that were otherwise inaccessible. For each olive-sided flycatcher detected we recorded observer location, distance and bearing to the bird, and the habitat type the bird was singing from.

Surveys were conducted in a wide range of cover types including mature, closed canopy forest, harvest units (e.g. seed tree and clearcuts), and small natural openings (e.g. ponds and bogs) (Table 1). Other types of open habitat used by olive-sided flycatchers, such as naturally open forest and post-fire habitat, were not available in the study area. Since surveys were conducted systematically along roads the number of stops per cover type is presumably proportional to the amount of each cover type in the study area. Although surveys were conducted from roads or trails, high road densities and the ability to detect these flycatchers at up to 800 meters ensured that the majority of the study area was sampled.

Table 1. Names and definitions of major forest cover types surveyed in the study area.

Cover Type	Description
mature forest	usually multi-storied, most trees 20 to 40 cm (7.9 to 15.7 in.) in diameter
thinned mature	as in mature, but a relatively small proportion of trees removed; generally at least 20% canopy cover remains
shelterwood	large proportion of mature trees removed, small trees may remain; mature overstory trees usually uniformly spaced, with an orchard like appearance
seed tree cut	most trees removed, a few widely spaced mature trees left as a seed source
clearcut	nearly all trees removed, a few snags and deformed or small trees remain
regenerating clearcut	as in clearcut but regenerating trees are in the pole/sapling growth stage growing in dense stands; trees are generally 10-20 cm (3.9-7.9 in) in diameter
thinned clearcut	as in regenerating clearcut but about half the pole trees have been removed; canopy and structure is more open

Phase two began on 16 June when we returned to detection sites to search for nests. We recorded the location of each nest found using a GPS unit (Garmin®) and mapped and photographed nest sites to document habitat types. We monitored nests every two to five days, or as often as time permitted. Nest stage and number of eggs or young was determined when possible by examining nest contents using mirror-poles or by observing nests using binoculars or a spotting scope. We followed standard methods

to minimize observer induced disturbance while monitoring, such as not approaching the nest when potential nest predators were known to be in the area (Martin 1993).

A nest was defined as successful when at least one nestling survived to leave the nest (i.e. fledged). Evidence of nest success included observing one or more fledglings, finding the nest empty and intact (i.e. no evidence of predation) within two days of the projected fledge date, or observing an adult carrying food or aggressively defending the area around the empty nest after this date. We calculated nest success as the proportion of successful nests relative to the total number of active nests (Martin 1992).

We examined failed nests when possible for evidence of the cause of failure. Nests were considered depredated if remains were found in the nest, or if the eggs or young were removed prior to the two-day period preceding the expected fledge date. We observed pairs with nests that appeared to fail within two days of the expected fledge date for extended periods of time to confirm they were not feeding fledglings. Pairs with nests that failed were monitored through the remainder of the breeding season to determine if additional nesting attempts were made. Breeding pairs were considered successful if they produced at least one fledgling from any nesting attempt.

At the end of the nesting cycle we measured vegetation at four scales: 1) at the nest, 2) nest tree, 3) within an 11.3-m (37-ft) radius nest plot, and 4) within a 50-m (164-ft) radius plot surrounding the nest tree (following Altman 2000 with modifications). Nest data sheets are shown in Appendix 1. Nest site characteristics measured included nest concealment, placement on branch, and distance from the nest to the trunk, top of tree, outer foliage, and to foliage above the nest. At nest trees we recorded species, height, percent crown foliage, and diameter at breast height (dbh). The distance between the nest tree and the nearest tree at least as tall as the nest height was recorded, as were slope and aspect. In an 11.3-m radius plot around the nest tree we tallied all trees greater than 10 ft and recorded tree species, dbh, height, whether the top was broken or dead, and the percent crown foliage. We also made ocular estimates for canopy cover by trees >40 ft, trees >10 ft, conifers < 10 ft, and shrubs >1.6 ft tall. Downed coarse woody debris was tallied in three size categories; < 8 in, 8-16 in, and >16 in. We recorded height, dbh, and distance from the nest for all snags and broken or dead topped trees within 50 m of the nest tree. We also recorded the distance to riparian zones within 100 m (328 ft) of nests and characterized the riparian habitat.

Habitat types within 100 m of the nest tree were classified into cover types following Hutto and Young (1999) with some modifications (Table 1) and distance and bearing to each habitat type was recorded. Cover type classification and vegetation data collected at each nest was used to define stand types that could serve as treatment types. We compared stand type classifications to Plum Creek Timber Company (PCTC) satellite structure data in order to measure agreement between the two different classification schemes.

Data were analyzed to determine which vegetation features were correlated with nest success. Pooled t-tests or Wilcoxn signed rank tests were used, depending on whether data were normally distributed, to determine whether there were significant differences in nesting success. P-values of $\leq .1$ were considered significant.

RESULTS

Project Effort and Cost

One full-time field technician (Ty Smucker) began field work in the Seeley study area on 22 May and surveyed approximately 80% of the study area. Nest searching started around the middle of June with monitoring of renests continuing until the middle of August. The field technician worked an average of 55 hours per week for 12 weeks for a total of 660 person hours. Vegetation plots were measured with an assistant (K. Smucker or H. Stabins) and took an additional 84 person hours to complete. Approximately 3000 miles were driven on forest roads while conducting surveys, searching for and monitoring nests, and collecting habitat data at nest sites.

The amount of time and effort required for locating nests was influenced by density of vegetation and by behavior of nesting pairs. Nests in dense regenerating cover types required more time to locate than nests in more open habitat types. Olive-sided flycatchers were most active during the nest building and nestling phases of the nest cycle and consequently nests were easier to locate during these phases than during incubation.

Detection Surveys

Surveys for singing male olive-sided flycatchers began on 22 May. The first two singing males were detected on 27 May (Figure 2). During the next four days the number of detections increased dramatically, with a total of 20 detections by 31 May. Females were first detected with males in the study area on 7 June and courtship displays were observed among several pairs. Upon the arrival of females and pairing with males, the "pipping" call note became common and was useful for detecting new pairs. Males paired with females began pipping regularly and singing less frequently. Pipping by females was less frequent and higher in pitch than pipping by males (T. Smucker personal observations). The number of detections increased steadily during the first three weeks of June.

We recorded 53 different olive-sided flycatchers in the Seeley study area throughout the field season (Table 2). Out of 53 separate detections of singing olive-sided flycatchers, 51 were located within or on the edge of harvested forest types such as regenerating clearcuts, seed tree cuts, and shelterwood cuts. Two additional detections were in natural openings on the edge of marshes, but no detections occurred within mature, closed canopy forest.

Table 2. Numbers of singing males detected during surveys, pairs exhibiting nesting behavior, and nests found. Nest fates are presented for nests found at different stages.

	Total number	Nest Fate	
Singing males detected	53		
Pairs exhibiting nesting behavior	32	Successful	Failed
Nests found during building or incubation	10	3	7
Nests found during the nestling stage	11	8	3
Total number nests found	21	11	10

Approximately 38% of the olive-sided flycatcher detections resulted in the location of breeding pairs and subsequent monitoring of their nests (n = 20). Eleven additional pairs were observed exhibiting behavior indicating that they were nesting (i.e. observed with nesting material or food, or defending the area near a suspected nest). One detection was suspected to be an unpaired male that continued to sing frequently and maintain a territory throughout the breeding season.

Breeding Chronology

The first nest was found on 16 June as the female was completing nest construction (Figure 2). This female was observed flying to the nest with lichen in her bill that she used to line and shape the inside of the nest. Two additional nests were found during middle and late building stages on 18 June, and a fourth nest was found during late building on 25 June. Females were first observed incubating eggs in these nests on 23, 25, 25, and 28 June, respectively. In addition, the only nest for which the first day of incubation is known contained three eggs when it was found on 25 June and four eggs upon the next nest check. Backdating from hatch dates shows that at least two nesting pairs may have initiated incubation as early as 20 June.

♂ ♀ B I N F F_r

-----27----*--7--------16------23------*--3----------------19-----------*-----------12------

May **June** **July** **August**

Figure 2. Timeline depicting olive-sided flycatcher breeding chronology. Grey shading shows the time interval. Numbers on dashed line indicate dates of first observations. ♂- male arrival, ♀- female arrival, B- nest Building, I- Incubation, N- Nestling stage, F- Fledge, F_r- re-nests Fledge.

The first nest containing nestlings was found on 3 July. Ten additional nests were found during the nestling stage when adults were making frequent trips to and from nests. Fledging dates for these nests were estimated between 19 and 30 July, including two nests that were confirmed as fledging on 25 July. Only one pair was observed attempting to renest. This renest was found on 7 August during the nestling stage 243 m (797 ft) from the pairs' first nest, and fledged young on approximately 12 August.

We were able to determine the number of eggs or young in ten nests by either checking the contents or observing the nests with binoculars when nestlings were large enough to be visible in the nest (Figure 3). Most nests for which clutch size could be determined had three or four young, while three nests were known to fledge only two young. For the remaining eleven nests we were unable to check the contents or observe nestlings at a late stage, and many of these nests may have had larger clutches than the minimum numbers reported.

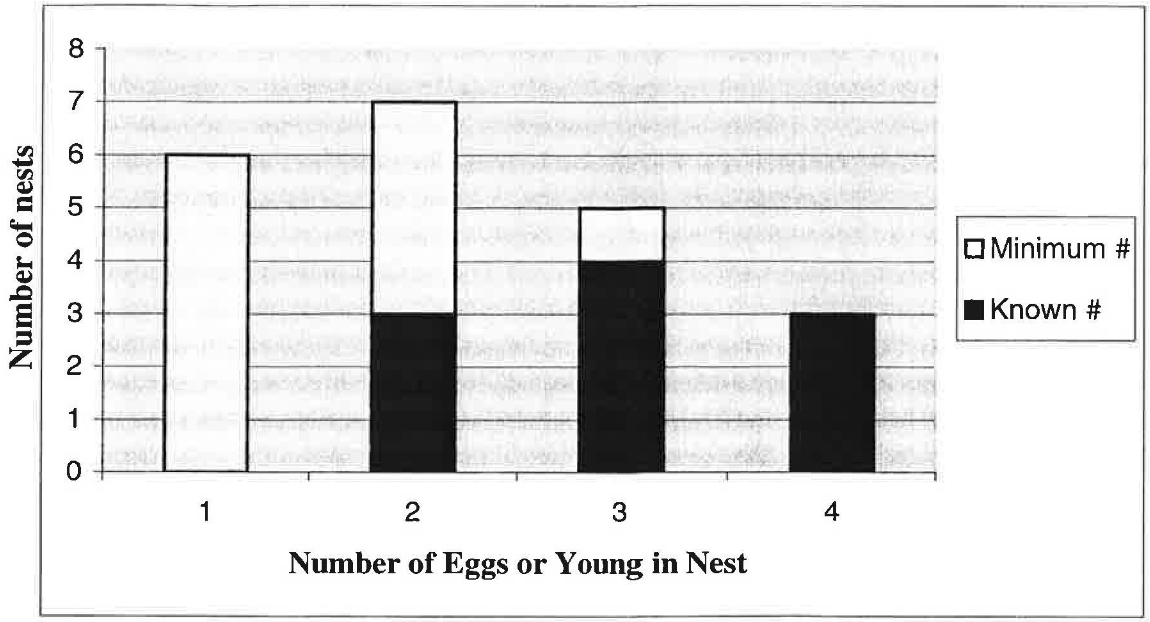

Figure 3. Minimum and known clutch sizes for olive-sided flycatchers based on numbers of eggs or young in nest; n = 21 nests.

Nest Success

We located and monitored 21 nests of 20 olive-sided flycatcher pairs in the Seeley study area. The proportion of successful nests was 50% for all first nesting attempts and 52.38% for all nests including the one renest (Table 3A). Pair success was 55% overall. Only three of ten nests found during building, incubating, or early brooding were confirmed to have survived in the nestling stage, i.e. observed nestlings or adults feeding nestlings. Eight of eleven nests (79% including the renest) found during the nestling stage successfully fledged young.

Olive-sided flycatcher pairs were observed aggressively defending nesting territories against a number of potential avian and mammalian predators including gray jays (*Perisoreus canadensis*), Steller's jays (*Cyanocitta cristata*), Clark's nutcrackers (*Nucifraga columbiana*), common ravens (*Corvus corax*), red squirrels (*Tamiasciurus hudsonicus*), and chipmunks (*Eutamias* spp.). American kestrels (*Falco sparverius*) and red-tailed hawks (*Buteo jamaicensis*) were also seen in vicinity of three active nests. Adult flycatchers appeared to limit activity around these three nests until raptors left the area (T. Smucker, personal observations). Additional potential nest predators in the study area include forest accipiters (*Accipiter* spp.).

One nest containing two eggs was confirmed as abandoned during the incubation stage. No instances of nest parasitism by brown-headed cowbirds (*Molothrus ater*) were confirmed, although one female cowbird perched within 50 m of a nest appeared to be watching a female olive-sided flycatcher as she completed building. Two olive-sided flycatcher and no brown-headed cowbird nestlings were observed in this nest prior to being depredated.

Nest Site Characteristics

Engelmann spruce and subalpine fir were most commonly used for nesting, with each tree species containing nine (43%) of the 21 nests. Two of the remaining nests were in Douglas-fir and one was in a western larch. The mean height of all nest trees was 50 ft and the mean dbh was 8.7 in. None of the nest site characteristics were significantly correlated with nest success.

Nests were generally placed away from the trunk on a main branch (mean = 27.0 in; range = 0-66 in). However, six of the 21 nests (28.6%) were placed directly against the trunk of the nest tree and experienced greater nest success (Table 3A). Nests placed against the trunk were generally in shorter, smaller diameter trees and nests were located closer to the top of the tree.

In the 11.3-m nest plot surrounding the nest tree canopy cover above 10 ft ranged from 2% to 45% with a mean of 18% across all nests. Mean canopy cover greater than 40 ft was 7.9%, reflecting an open stand structure. The mean numbers of trees greater than 40 ft and greater than 10 ft tall in the nest plot were five and 24, respectively. See Appendix 2 for means and ranges of all vegetation measurements taken at the nest tree. Nests placed against the trunk had higher canopy cover under 40 ft, greater tree density in the nest plot, higher shrub cover, and fewer snags (Table 3B). Five of the six nests placed against the trunk were in either regenerating or thinned clearcut cover types.

Table 3A. Mean $\pm$ standard error (SE) of nest tree variables for all nests, nests placed against the trunk, and nests away from the trunk.

Nest Placement	Distance from trunk (in)	% Success	Tree dbh (in)	Tree Height (ft)	Distance to top (ft)	Distance to Outer Foliage (in)	Distance to foliage above nest (in)
All Nests (n=21)	27.0 $\pm$ 4.4	52.4	8.7 $\pm$ 1.1	50 $\pm$ 5.4	14.8 $\pm$ 2	19.1 $\pm$ 4	15.5 $\pm$ 3.6
Against Trunk (n=6)	0	66.7	5.6 $\pm$ .5	32 $\pm$ 2.6	5.5 $\pm$ .6	8.0 $\pm$ 1.5	4.7 $\pm$ .3
Away from Trunk (n=15)	37.7 $\pm$ 3.2	33.3	9.9 $\pm$ 1.4	57 $\pm$ 6.7	18.5 $\pm$ 2	23.6 $\pm$ 5.2	19.8 $\pm$ 4.7

Table 3B. Mean $\pm$ SE of nest plot variables for all nests and grouped by nest placement.

Nest Placement	% Canopy Cover >10 ft	% Canopy Cover >40 ft	# Trees in nest plot >10 ft	% Deciduous Shrub Cover	# Small CWD	# Snags w/in 50m
All Nests (n=21)	18 $\pm$ 3	8 $\pm$ 3	24 $\pm$ 4	32 $\pm$ 8	30 $\pm$ 6	25 $\pm$ 4
Against Trunk (n=6)	23 $\pm$ 6	1 $\pm$ 1	34 $\pm$ 7	46 $\pm$ 17	46 $\pm$ 17*	14 $\pm$ 3
Away from Trunk (n=15)	16 $\pm$ 4	11 $\pm$ 3	21 $\pm$ 4	26 $\pm$ 8	23 $\pm$ 5*	29 $\pm$ 5

* 3 nests against the trunk and 1 nest away from trunk in thinned clearcut cover types.

Nest success was significantly higher (p-value < .05) at nests with a high percent shrub cover and a smaller number of snags within 50 m of the nest tree (Table 4). The total number of snags at multiple distances from the nest was examined. The number of snags within 20 m of the nest was similar at successful and failed nests, but at 25 m failed nests had greater numbers of snags than successful nests. Nest success was also correlated (p- value < .1) with a greater amount of large diameter (> 16 in) downed coarse woody debris and fewer trees greater than 10 ft within the nest plot.

Table 4. Mean $\pm$ SE of plot variables correlated with successful and failed nests.

	% shrub cover in nest plot[a]	large CWD in nest plot[b]	# trees >10 ft in nest plot[b]	# snags within 50m[a]
Successful nests (n = 11)	44 $\pm$ 11	1.3 $\pm$ .4	20 $\pm$ 5	18 $\pm$ 4
Failed nests (n = 10)	18 $\pm$ 9	.5 $\pm$ .2	30 $\pm$ 6	31 $\pm$ 6

[a] significant difference at p < .05, [b] significant difference at p < .10

Nest Stand Characteristics

Fifteen olive-sided flycatcher nests were found on PCTC land and an additional six nests were found on adjacent US Forest Service land. All nests were found either within open or semi-open managed forest or in mature forest on the edge of harvest units (Table 5), where edge is defined as within 30 m of another cover type. Six nests were found along edges between mature forest and open cover types, with three nests located in mature forest or mature forest patches (such as riparian management zones) bordering harvest units.

Four stand types were identified based on forest structure and the number of trees and coarse woody debris in the 11.3-m nest plot (Table 5). The mature forest stand type had more trees greater than 40 ft in the nest plot than any other cover type while regenerating clearcut stands had the highest density of trees greater than 10 ft (see Appendix 3 for photographs of stand types). The thinned forest stand type included both thinned mature and thinned clearcut cover types. This stand type had fewer trees and more coarse woody debris in the nest plot than either the mature forest or regenerating clearcut stand types and. A gradation exists in the number of trees remaining in clearcuts, seed tree cuts, and shelterwood cuts and clear differences between these types were often not discernable. For this reason these three cover types were lumped as green-tree retention stands and are characterized by having fewer trees in the nest plot than any other stand type. There were no significant differences in nest success between stand types.

Table 5. Stand types, cover types, mean (± SE) number of trees greater than 10 ft and greater than 40 ft, number of nests on the edge, and total number of nests (with number of successful nests in parentheses) per treatment type.

Stand type	Cover type	# trees >10 ft	# trees >40 ft	# nests on edge	total # nests
mature forest		31 ± 5	13 ± 2	3	3(2)
regenerating clearcut		50 ± 4	5 ± 2	0	4(2)
thinned forest	thinned mature thinned clearcut	23 ± 6	3 ± 2	1	6(3)
green-tree retention	clearcut seed tree cut shelterwood	10 ± 2	3 ± 1	2	8(3)

Stand types classified according to habitat data at nest sites are compared with PCTC satellite data on vegetation and habitat structure types in Table 6. Satellite vegetation types were not useful for comparison with habitat data at nest sites. At a very coarse scale satellite vegetation types indicated the presence of some conifer forest structure, but tree species and type typically did not corresponded with nest stand types. The foothills grassland vegetation type seemed to correspond with recently managed stands and included nest sites in recent seed tree cuts, thinned pole sapling, and thinned forest stands with low shrub cover. Satellite structure data are shown in Table 6 as version 1 and version 2, where version 2 resulted from reclassifying stands using a different model. Agreement between nest stand type designations and satellite structure data was 78% for version 1 and 62% for version 2. The version 2 satellite structure data appeared to incorrectly classify a number of green tree retention, regenerating clearcut, and thinned forest stands as old forest high/low.

Table 6. Nest fate and stand type compared with satellite vegetation and two versions of satellite structure data for each nest. Agreement between stand type and satellite vegetation or structure classification is indicated by same color. Satellite data that do not correspond with stand types are marked with * and shown in pink.

Nest #	Fate	Stand Type	Satellite Vegetation Type	Version 1 Sat Structure	Version 2 Sat Structure
1	FAIL	GTR	foothills grassland*	SIL	SIL
2	FAIL	GTR	mixed mesic conifer forest	URL*	OFL*
3	FAIL	GTR	mixed xeric conifer forest	SIL	URL*
5E	FLEDGE	GTR	ponderosa pine*	SIL	SIL
10	FLEDGE	GTR	foothills grassland*	SIL	OFH*
11E	FAIL	GTR	mixed subalpine forest	SEL	SIHA
15	FAIL	GTR	shrub dominated clearcut	SIL	SEH
20	FLEDGE	GTR	No Data	No Data	SIHB
4E	FAIL	MF	mixed mesic conifer forest	URL*	OFL
9E	FLEDGE	MF	mixed mesic conifer forest	SIH*	OFL
21E	FLEDGE	MF	No Data	No Data	OFH
8	FAIL	Reg	mixed mesic conifer forest	NF*	OFH*
14	FAIL	Reg	lodgepole pine	SIL	OFH*
18	FLEDGE	Reg	lodgepole pine	SIH	URH
19	FLEDGE	Reg	No Data	No Data	SEH
6	FAIL	ThF	mixed mesic conifer forest	URL	SIHA*
7E	FAIL	ThF	mixed mesic conifer forest	URL	OFH*
12	FLEDGE	ThF	lodgepole pine	SIH	OFH*
13	FLEDGE	ThF	foothills grassland*	SIL	URL
16	FAIL	ThF	foothills grassland*	SIL	URL
17	FLEDGE	ThF	foothills grassland*	SIL	SIM

#E denotes nests within 30m of a habitat edge
Stand types: GTR=Green Tree Retention, MF=Mature Forest. Reg=regenerating clearcut, ThF=Thinned Forest. Satellite vegetation and structure type (Sat Str-old and new) data provided by PCTC: SIL/M/H=Stand Initiation Low/Medium/High(A,B), SEL/H=Stem Exclusion Low/High, URL/H=Understory Reinitiation Low/High, OFL/H=Old Forest Low/High.
See Appendix 4 for a description of satellite structure types.

DISCUSSION

Data from the Northern Region Landbird Monitoring Program shows that in western Montana and Idaho the olive-sided flycatcher is detected on 12% of points in seed tree cuts, 9% of points in old clearcuts at the pole sapling stage, 7% of points in younger clearcuts, and 6% of points in post-fire habitat (Hutto & Young 1999). This flycatcher was detected at less than 5% of the points in all other forest types, including mature and old growth forest.

Surveys for singing males in the Seeley Lake area reflected this preference for open habitat types created by timber harvest. Most singing males were found within or on the edge of harvested forest types. A few olive-sided flycatchers were detected on the edge of mature, closed canopy forest, but never within mature stand types. The two detections on marsh edges indicate that olive-sided flycatchers also use naturally open

habitat, but since these cover types were rare in the study area we could not investigate whether flycatchers prefer forest types that are open naturally or due to management activities.

The first singing males were detected in the study area within the range of the earliest detection dates reported elsewhere in western North American (Altman & Sallabanks 2000). Nest building occurred one to three weeks later than average initiation dates for olive-sided flycatchers in Oregon (Altman 2000), but it is likely that building began earlier than we detected since the first nest was discovered at the late building stage. Mean fledge dates were within the range of those reported by other studies (Altman 2000; Altman & Sallabanks 2000).

Clutch sizes ranged from two to four, but we were unable to calculate the average clutch size due to the large number of high nests for which the contents could not be examined. The majority of nests that survived to the nestling stage went on to fledge at least one young, indicating that nest mortality in the Seeley study area may be highest during incubation. In contrast, 60% of failures in central Alaska occurred during the nestling phase (Wright 1997) and Altman (2000) reported that nest failure was relatively equal between incubation and nestling phases.

Proportional nest success was 50% in the Seeley study area, which is similar to nest success rates reported in other areas (Wright 1997; Altman 2000). However 70% of nests found during the incubation phase failed, while the majority of nests (73%) found during the nestling stage fledged. The large number of nests found late in the nesting cycle may have biased our estimate toward success because these nests had already survived the high mortality incubation phase. Due to our small sample size we were unable to calculate daily nest survival rates which would have accounted for this fact. For this reason our estimate of nest success (50%) should be considered a maximum, and actual nest success may be considerably lower.

Predation is speculated to be the primary cause of nest failure in this and other studies of olive-sided flycatcher nesting success (Wright 1997; Altman 2000). We do not suspect that parasitism by brown-headed cowbirds is an important factor affecting nest success for two reasons: 1) there is no cattle grazing in forests within or adjacent to the study area, and thus few cowbirds, and 2) olive-sided flycatchers defend their nests aggressively against intruders. Only one nest was confirmed as abandoned during the incubation stage and so predation remains the most likely explanation for failure.

Although predation events were not observed during this study, a variety of corvids, raptors, and small mammals such as red squirrels and chipmunks are common in the study area. Altman (1999) reported the only direct observation of a depredated olive-sided flycatcher nest, in which a gray jay removed two eggs from the nest. Chipmunks, red-tailed hawks, and American kestrels are typically associated with open habitat types, while red squirrels, corvids, and accipiters are generally associated with mature forests (Andren 1992, , Mills et al. unpublished data). Corvids were most often suspected as nest predators in this study and in Altman's (2000) study despite the fact that olive-sided flycatcher nests are generally found in open habitat types. For this reason it is important to identify actual nest predators and measure their abundances.

Previous studies have reported a preference for hemlock and true firs for nest trees (Altman & Sallabanks 2000), suggesting this is because nests are woven into the foliage of flat boughs typical of these species. Hemlock and true firs also have a greater

foliage density than any of the other tree species commonly found in their study areas. In this study nests did not appear to be woven into the needles as reported by Altman (2000), but were supported by the main branch and small side branches. However, olive-sided flycatchers did nest most frequently in the two tree species with the greatest foliage density. We did not examine use versus availability in this study, but Douglas-fir, western larch, and lodgepole pine are more abundant than spruce and fir within the study area, and yet 89% of all nests were located in either Engelmann spruce or subalpine fir.

Most nests were placed away from the trunk. However, the six nests found directly against the trunk of the nest tree represent a higher proportion than found in previous studies. In instances where the nest was placed against the trunk, nest trees were generally smaller with nests placed closer to the top of the tree (Table 3A). In addition, the mean canopy cover > 40 ft was lower while canopy cover and the number of trees > 10 ft were higher for nests placed against the trunk (Table 3B). This indicates that these trees were in young, dense stands with few large trees, and indeed five nests were in regenerating clearcuts. Thus it appears that nests may have been placed against the trunk simply because the trees were too small to place nests further out on the bough and there were few large trees available.

Murphy (1983) suggested that placing nests away from the trunk increases nest success in eastern kingbirds. In this study, however, nest success was actually higher (66.6%) for nests against the trunk than those placed away from the trunk. Small sample size limits our ability to interpret this finding because there are several possible explanations at the nest tree and stand level. For example, increased nest success may be due to placement against the trunk, or it may be because the stand type is a regenerating clearcut composed of smaller, more densely stocked trees which facilitate success.

Since nest concealment was not correlated with nest success we suspect that there may be other vegetation features that contribute to nest success. While small sample size limits our ability to draw strong inferences, two variables do appeared to be positively correlated with nest success. Nest success was significantly higher when shrub cover was high and when there was more large coarse woody debris. A well developed shrub layer and downed wood may support higher numbers of insects, particularly aerial insects such as bees, wasps, and termites that are the primary prey for olive-sided flycatchers (Altman & Sallabanks 2000).

Nest success was inversely correlated with the number of snags and the number of trees greater than 10 ft. This was an unexpected result because we suspected that the availability of snags and trees, which could serve as perch sites near the nest, might be important in the early detection of predators. Perhaps a minimum number of snags and trees are needed for perch sites, but beyond some ideal number high tree and snag densities simply offer more perch sites for predators. Additionally, the mean number of snags within 20m of the nest was similar at failed and successful nests, but failed nests tended to have more snags when a larger radius was used to analyze snag data. This may indicate that high numbers of snags greater than 20m from the nest are correlated with decreased nest success, or it may simply be an artifact of small sample size.

In the proposal for this study we stated that we would select treatment types and compare nest success in different types of managed forest. It was very difficult to classify habitat used by olive-sided flycatchers into distinct treatment types before we analyzed the vegetation data collected at each nest. Current forestry practices have

moved away from implementing strict harvest treatments, such as clearcuts and seed tree cuts, and are instead using green tree retention harvests to leave residual habitat for wildlife. The result of this shift in management is that harvest units now provide a gradient in habitat features such as the number, size, and distribution of trees retained, and harvest type distinctions such as seed tree cut versus shelterwood cut become difficult to define.

We identified four distinct stand types that could be considered treatment types: mature forest, thinned forest, regenerating clearcuts, and green tree retention cuts. Stand type distinctions were based on forest structure and the number of trees and downed coarse woody debris within the nest plot. We were unable to detect significant differences in nest success among treatment types, but this is likely due to small sample size. However, it is also possible that other types of vegetation variables, such as shrub cover and coarse woody debris, need to be accounted for when creating meaningful treatment types. Our limited sample size prevented a more comprehensive examination of vegetation variables that could be used to define treatment types.

Agreement between stand type classifications of olive-sided flycatcher nest sites and PCTC satellite vegetation and structure data was generally low. The satellite structure class SIL (stem initiation low) corresponded with three different stand type designations: green tree retentions, regenerating clearcuts, and thinned forest. This indicates that the criteria we used to designate stand types did not correspond closely with criteria PCTC used to classify satellite vegetation and structure data. In addition to using different criteria, the satellite structure classes OFH and OFL (old forest high/low) were incorrectly assigned to several green tree retention and regenerating clearcut stand types. For these reasons, the current forms of the satellite structure and vegetation data were not helpful in classifying olive-sided flycatcher nest habitat.

Management Implications

Based on the number of detections of singing males within the study area it appears that olive-sided flycatchers are a relatively common breeding bird in the Seeley Lake area. Most detections were within or on the edge of harvest units, indicating that managed lands provide the majority of nesting habitat in the area. However, this study does not address whether managed lands provide high quality breeding habitat, as compared to naturally open and post-fire habitat. Because olive-sided flycatchers have a low reproductive rate, high nest success may be important to sustain populations (Altman & Sallabanks 2000). For this reason it is possible that our proportional estimates of nest success at 50%, which may be biased high, are not high enough to sustain healthy populations.

In this study, olive-sided flycatchers nested most frequently in subalpine fir and Engelmann spruce trees. These tree species may be important to flycatchers because their flat, dense bough structure provides a platform for nest construction. Both of these trees are found at slightly higher elevations and in more mesic habitat, such as along streams. If flycatchers are selecting these two tree species more frequently than others, then it may be important to manage some spruce/subalpine fir forests as olive-sided flycatcher habitat.

High shrub cover and greater amounts of large coarse woody debris were correlated with nest success and may be important components in stands that are managed as olive-sided flycatcher habitat. If insect abundance is actually higher in stands with high shrub cover and greater densities of coarse woody debris, and if insect abundance is positively correlated with nest success, then these vegetation characteristics may be important proximate drivers of nest success. There is also evidence that nest success is negatively correlated with higher densities of trees and snags near the nest, but these habitat variables warrant further study.

Future Studies

Despite the low number of nests located and monitored, the number and distribution of detections during the 2001 breeding season indicate that olive-sided flycatchers are relatively common in the study area, but widely dispersed with a patchy distribution. Therefore, obtaining an adequate sample size for a study of this species appears to be limited more by the number of field personnel available to locate and monitor breeding pairs than by the species' abundance in the Seeley area.

The results of this study show that olive-sided flycatchers nest readily in harvest units. The next logical step is to compare nest success between managed lands and natural, post-fire habitat. The Seeley area would be an ideal place to conduct a study to examine the "ecological trap" hypothesis in which harvest units resemble naturally open post-fire habitat, but do not offer high quality breeding habitat. Managed lands in the Seeley area could be paired with natural habitat in Bob Marshall Wilderness Area that burned in the 2000 Monture Fire.

Given that vegetation variables such as shrub cover and coarse woody debris were correlated with nest success, it is likely that olive-sided flycatchers experience differential success between stand types. In this study stand types were defined based on forest structure and the number of trees within the nest plot. Future studies should identify other variables that may be correlated with nest success that could be used to refine stand type definitions. The most effective way to identify these variables would be to collect vegetation data at nests from the entire range of managed and unmanaged stand types used by olive-sided flycatchers. Once vegetation features correlated with nest success are identified, meaningful stand type definitions could be created for olive-sided flycatchers.

Future studies should investigate proximate factors related to nest success such as abundance of insect prey and potential nest predators. High insect abundance or increased availability may be correlated with nest success and specific vegetation characteristics. In addition, various stand types support different species and densities of potential nest predators. Correlating insect availability and nest predation rates with vegetation features may be useful in formulating management recommendations for olive-sided flycatchers.

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Appendix 1. Olive-sided Flycatcher Nest Data Sheet- Summer 2001

Nest Number:____ UTM _______________N ________________E Date:__________

Orientation_____ Height____ft Distance to top of tree_______in

to trunk____ to outer foliage___ to nearest foliage above nest_____

concealment______ Placement________________________________

Slope________ Aspect________ Location_____________________________

11.3 m Plot: Canopy Cover (>40 ft) ______%

Shrub Layer (1-10ft) Deciduous______% Conifer _______%

CWD: Small <8in _____Thin? Medium 8-16in_______ Large >16in______

Distance to nearest tree/snag (taller than nest height) from nest_________m *A

Trees >10 ft tall in 11.3m and 36 m plot (____% 36m plot in adjacent habitat type)

SPECIES	DBH	HEIGHT	TOP L/D	%FOL	SPECIES	DBH	HT	L/D	%FOL
*N									
*A									

Snag count w/in 50 m

Distance	Bearing	Height	DBH		Distance	Bearing	Height	DBH

	LBMP code	PC code	Dist.	Bearing
Nest COV TYPE				
EDGE 1				
EDGE 2				
EDGE 3				

Distance to riparian______ riparian habitat width________ riparian type/width_______

Shrub layer____________ Mean tree ht, dbh, #/10m ____________________________

Sub Plot #1: Distance________ Bearing______R? Cov Type________________

11.3 m Plot: Canopy Cover (>40 ft) ______%

Shrub Layer (1-10ft) Deciduous______% Conifer _______%

CWD: Small <8in _______Th? Medium 8-16in_______ Large >16in______

Trees and snags >10 ft tall

SPECIES	DBH	HEIGHT	TOP L/D	% FOL	SP	DBH	HT	L/D	%FOL

Sub Plot #2: Distance________ Bearing_________ Cov Type_________________
11.3 m Plot: Canopy Cover (>40 ft) ______%

Shrub Layer (1-10ft) Deciduous______% Conifer _______%

CWD: Small <8in _______Th? Medium 8-16in_______ Large >16in______

Trees and snags >10 ft tall

SPECIES	DBH	HEIGHT	TOP L/D	% FOL	SP	DBH	HT	L/D	%FOL

Sub-Plot #3: Distance________ Bearing________ Cov Type__________________
11.3 m Plot: Canopy Cover (>40 ft) ______%

Shrub Layer (1-10ft) Deciduous______% Conifer _______%

CWD: Small <8in _______Th? Medium 8-16in_______ Large >16in______

Trees and snags >10 ft tall

SPECIES	DBH	HEIGHT	TOP L/D	% FOL	SP	DBH	HT	L/D	%FOL

Comments:____

Olive-sided Flycatcher Nest Data Sheet- Summer 2001
Tree Data Supplement Sheet

Nest Number:____ UTM ______________N _______________E Date:_________

Trees >10 ft tall in 11.3m and 36 m plot (____% 36m plot in adjacent habitat type)

SPECIES	DBH	HEIGHT	TOP L/D	%FOL	SPECIES	DBH	HT	L/D	%FOL
*N									
*A									

Snag count w/in 50 m

Distance	Bearing	Height	DBH		Distance	Bearing	Height	DBH

Sub Plot #_____: Distance________ Bearing______R? Cov Type_______________

Trees and snags >10 ft tall

SPECIES	DBH	HEIGHT	TOP L/D	% FOL	SP	DBH	HT	L/D	%FOL

Appendix 2. Mean and range for vegetation measurements at failed, successful, and all nests within the Seeley Lake Study Area (n = 21 nests).

Vegetation Variable	Failed Nests	Successful Nests	All Nests
Nest tree:			
dbh (in)	**7.9** (4.3-14)	**9.4** (3.5-23.2)	**8.7** (3.5-23.2)
tree height (ft)	**48** (25-88)	**52** (23-124)	**50** (23-124)
distance to top of tree (ft)	**12** (4-24)	**17** (4-33)	**15** (4-33)
distance to trunk (in)	**24** (0-40)	**30** (0-66)	**27** (0-66)
distance to outer foliage (in)	**16** (1-42)	**22** (4-84)	**19** (1-84)
distance to foliage above nest (in)	**13** (5-36)	**18** (4-72)	**16** (4-72)
concealment rating (scale of 1 to 4)	**3** (1-4)	**2.8** (2-4)	**2.9** (1-4)
distance to nearest tree (ft)	**11.2** (3.3-23.8)	**16.4** (5.6-31.2)	**14.1** (3.3-31.2)
distance to nearest edge (ft)	**125** (49-262)	**95** (16-164)	**112** (16-262)
distance to riparian zone (ft)	**194** (36-328)	**197** (3-394)	**194** (3-394)
Within 11.3-m radius plot:			
% canopy cover >10 ft	**16** (1-42)	**19** (4-84)	**18** (1-84)
% canopy cover > 40ft	**6** (0-30)	**9.6** (0-40)	**7.9** (0.40)
% cover by conifers <10 ft	**10.5** (5-20)	**6.2** (0-20)	**8.2** (0-20)
% shrub cover	**18**[a] (0-80)	**44**[a] (1-90)	**32** (0-90)
count of small coarse woody debris	**34** (10-85)	**27** (2-100)	**30** (2-100)
count of medium coarse woody debris	**4.5** (1-11)	**4.7** (1-13)	**4.6** (1-13)
count of large coarse woody debris	**.5**[b] (0-1)	**1.3**[b] (0-3)	**.9** (0-3)
count of trees > 10ft	**30**[b] (4-58)	**20**[b] (4-53)	**24** (4-58)
count of trees > 40ft	**5** (0-16)	**4.5** (0-12)	**4.7** (0-16)
count of trees <10ft	**8.2** (2-26)	**8.5** (1-40)	**8.3** (1-40)
count of snags	**1.0** (0-2)	**.9** (0-7)	**1.0** (0-7)
Within 50m: count of snags	**31**[a] (3-50)	**19**[a] (5-69)	**25** (3-69)

[a] significantly different at p = .05; [b] significantly different at p = .1

Appendix 3. Photographs of the four stand types used by nesting olive-sided flycatchers.

Figure A1. Mature patch (riparian management zone) bordering ceanothus shrub field.

Figure A2. Thinned forest

Figure A3: Regenerating clearcut. These two photos show the range in forest age and structure, but overall tree density is significantly greater than other stand types.

Figure A4. Green-tree retention cuts. These two photographs demonstrate the range in structure and size class of trees, but open stand structure with few large trees.

Appendix 4. Satellite vegetation classification description.

Land Cover Classification in the Swan Valley/Clearwater/Lower Blackfoot Valley
Resource Cartographics, Philip Tanimoto, PO Box 9933, Moscow, ID 83843

Classification Definitions:

SIL: Stand Initiation Low: Early-seral consisting of a range of conditions from barren ground to seedling stage, without overstory.

SIM: Stand Initiation Medium: seedling-sapling stands.

SIH: Stand Inititation High: seedling-sapling stands with greater heterogeneity and density.

SIHA: Stand Initiation High, Sub-type a: scattered trees in an herbaceous matrix, without an differentiated understory, comprising a savannah-like habitat where total canopy closure generally ranges from 4% - 18%.

SIHB: Stand Initiation High, Sub-type b: stands with both overstory and understory where total canopy closure is generally less than 19%. Understory generally seedling-sapling.

SEL: Stem Exclusion Low: unevenly-distributed, pole-sized trees (average-size).

SEH: Stem Exclusion High: fairly even-sized, even-aged, pole sized trees, often planted and fairly dense. However, if lodgepole pine, unplanted. Canopy closure usually greater than 50%.

URL: Understory Reinitiation Low: heterogeneous stands with a minimum canopy closure of approximate 18%-20%. Average tree size larger than pole. Includes seed-tree and shelterwood stands without understory.

URH: Understory Reinitiation High: heterogeneous stands, often dense, with an average tree size larger than pole.

YFL: Young Forest Low: moderately large trees, variable density, tending toward relatively-even canopy.

YFH: Young Forest High: moderately large trees, variable density, tending toward relatively heterogeneous canopy structure.

OFL: Old Forest Low: older, larger trees, dense, representing an advanced seral class.

OFH: Old Forest High: older, larger trees, generally dense, representing the oldest, most-structurally-heterogeneous seral class.

Introduction

Landsat 5 TM and Landsat 7 ETM imagery were used to classify land cover type, crown closure, and forest structure across approximately1.8 million acres in western Montana in three project areas as follows:

Thompson Valley: 453,009 acres
Swan Valley: 456,965
Clearwater Divide/Lower Blackfoot Valley ("Clearwater" area): 872,178 acres

While the Thompson Valley was classified in a manner identical to the Swan Valley, this document describes classification only for the Swan and Clearwater areas.

The conjoined area of the Swan and Clearwater areas is 1,329,143 acres. The Swan and Clearwater areas were classified separately, under separate projects, using the same classification system for land cover, canopy closure, and structure.

The products created for the Swan and Clearwater areas were developed in three phases. Phase one covered the Swan area, phase two covered the Clearwater area, and phase three consisted of a classification of forest structure for the combined areas.

Phase I, Swan Area

Unsupervised classification
Using Envi image processing software (Research Systems, Inc., Boulder, CO, www.rsinc.com)
an unsupervised spectral classification algorithm was run on the Landsat 5 image yielding 50 spectral classes.

The resulting images were imported to Arc/Info

Selecting Polygons for photo-interpretation
The criteria used for selecting polygons were:
1. Must be covered by recent aerial photographs.
2. Must be of sufficient size (several pixels) to locate and trace the polygon on acetate covering aerial photographs.

To accomplish this, the unsupervised classification image data were vectorized in Arc/Info, resulting in a polygon coverage. All small polygons were removed from the data set in order to retain polygons of sufficient size to transfer to aerial photographs. The were assigned to class-specific polygon coverages.

On the computer display, the polygons from each class were superimposed over a false color composite of the satellite imagery as a geographic reference. The polygons were

then drawn onto acetate overlays on the aerial photographs and labeled with their polygon ID labels and class numbers.

Photo-interpretation

427 polygons were photo-interpreted. The mean number of polygons per spectral class was 13.8 (range 1-29).

All polygons were interpreted using a mirror stereoscope under 8x magnification.

Each polygon was assigned a 4-digit code representing a habitat type, a structure class, and a canopy closure class. Additional data included species composition, aspect, elevation, and miscellaneous notes. The habitat codes were modified from the Montana Gap Analysis Project. Crown closures were recorded in percent. Structure classes were assigned according to PCTC specifications.

Data were recorded on a paper form, and subsequently entered into Microsoft Excel. One Excel file was created for the polygons from each spectral class. The Excel spreadsheets were examined to interpret the modal habitat class, structure, and canopy class for each spectral class. Where no mode existed, or where data appeared to represent bi-modal habitat classes, an attempt was made to attribute observed patterns to slope, aspect, and/or elevation. An analysis of normalized difference vegetation index (NDVI) was also performed to refine structure class assignment.

The NDVI is an image processing product created by the following equation:

$$NDVI = (b4-b3)/(b4+b3)$$

where b4 and b3 are Landsat bands 4 and 3, respectively.

NDVI capitalizes upon the brightness of photosynthetic surfaces (leaves) in band4. The brightest NDVI pixels usually indicate dense shrubs. Low, moderate, and moderately-high elevated NDVI values indicate barren areas, sparser vegetation, conifer forests, or other cover types.

NDVI analysis was conducted interactively, on-screen, and with aerial photographs to make habitat type and structure class assignments.

The assignments made during P.I. and NDVI analysis were translated into an Arc/Info "docell" routine which calls a set of if-then statements contained in a text file which specify required parameters from one or more input grids to create an output grid. For example, the pixels of a particular output grid might be specified by the following criteria:

- exists in spectral class 23
- aspect is 270-360 degrees
- elevation is between 5,000 and 5,400 feet

- NDVI value is from 130-145

For each spectral class, several output grids could (and frequently were) produced. For each spectral class, three output grids (habitat type, crown closure class, and seral class) were produced. The output grids from each spectral class were subsequently combined to create continuous grids for each theme, covering the project areas.

An additional effort was made to locate probable Engelmann spruce stands by conducting a topographic analysis based on elevation, proximity to hydrologic features, and landform concavity.

Various other docell routines were run with the objective of refining the classifications or reassigning values to pixels in the output grids.

Phase II, Clearwater Divide/Lower Blackfoot Valley

Methods used for the second project area were generally similar to those used for the Swan Valley, with one important exception.

After conducting a process similar to that described above, Envi software was used to create several sets of pixels with known habitat characteristics. These sets defined "regions of interest" (ROIs). Each ROI is saved as a separate file for use in a supervised classification routine that classified the original satellite image bands into their most-likely habitat classes based upon the ROI spectral characteristics.

ROIs included the following cover classes:

- Agricultural circles and row crops
- Emergent aquatic plants
- Herbaceous-dominated clear cuts
- High, dense, subalpine forest
- Barren clear cuts
- Foothills grassland
- Sagebrush-grassland
- Shrub-dominated clear cut
- Sapling regeneration

The results of the supervised classification were used to update the existing classified land cover grid.

For both study areas, the contract deliverables were specified to conform to a 3-acre minimum mapping unit. Therefore, the Arc/Info ELIMINATE routine was used to aggregate the data. The software accomplishes this by merging small polygons with their neighbors. The process degrades the spatial resolution of the data.

Phase III, Structure Revision for Combined Areas

A review of the structure resulting from Phases I and II indicated that they could be improved upon to more accurately portray existing conditions. The decision was made to acquire a new Landsat 7 ETM+ image (August 03, 1999) for the new structure model. A new methodology was used. New (1999) aerial photos were also available for this project in the formed of scanned jpeg images provided on CD-ROM.

The aerial photo centers were digitized and labeled to locate them on the GIS screen.

An unsupervised classification was performed on the new imagery. The pixels from each spectral class were used to establish a set of GIS points within the areas for which new scanned photographs were available. This was accomplished by digitizing a set of points directly within the pixels from each unsupervised spectral class. The points were distributed throughout the area for which new photographs were available.

By using the GIS and a graphics program to view the aerial photo jpeg, the location of each digitized point was determined on the aerial photographs to assess structure and other habitat characteristics. Those attributes were assigned to each digitized point.

After developing a data base of 772 attributed points, the points were divided into groups defined by their structure class. The points from each structure class were then rasterized and the resulting grid was imported into Envi image processing software where they were used as ROIs in a supervised classification. The supervised classification incorporated the original satellite image bands, elevation, slope, and aspect. The resulting image contained a structure class code for all pixels in the project area.

Results from the unsupervised classification were imported into Arc Grid where the attribute table was updated with a character string representing the structure class for each pixel. A minimum mapping unit of 3 acres was established by using the MAJORITYFILTER function. This process proved superior to using the ELIMINATE command in a vector environment.

These products are intended for application to large-area modeling (e.g. watersheds & subwatersheds).